Effectiveness of different techniques for removing gutta-percha during retreatment

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Abstract

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Aim To evaluate the effectiveness of various techniques for removing filling material from root canals *in vitro*.

Methodology Eighty extracted mandibular premolar teeth were selected for the study. The teeth were root filled using thermomechanical compaction of gutta-percha. After 8 months, the filling material was removed and canals were reinstrumented using the following techniques: group I – hand instrumentation with K-type files (SybronEndo, Orange, CA, USA); group II – K3 Endo System (SybronEndo); group III – M4 system (SybronEndo) with K-type files (SybronEndo); and group IV – Endo-gripper system (Moyco Union Broach, York, PA, USA) with K-type files (SybronEndo). The amount of filling debris remaining on root canal walls was assessed radiographically; the images were digitized and analysed using AutoCAD 2000 software. Total canal area, area of the cervical, middle and apical thirds, and area of remaining filling material were outlined by one operator. The ratios between these areas were calculated as percentages of remaining debris. Thereafter, data were analysed by means of one-way ANOVA and the *post-hoc* Duncan test to identify differences between the four techniques.

Results Multiple comparisons of the percentages of remaining filling material in the entire canal did not reveal any significant differences between the methods of removal. However, when each third was analysed separately, significant differences for remaining debris were present between groups. The apical third had the most remaining material, whilst the cervical and middle thirds were significantly cleaner ($P = 0.002$). Comparison of the techniques revealed that teeth instrumented with K3 rotary instruments had a lower ratio of remaining filling material in the apical third ($P = 0.012$).

Conclusion In the apical third, K3 rotary instruments were more efficient in removing gutta-percha filling material than the other techniques, which were equally effective for the other thirds.

Keywords: gutta-percha, nickel-titanium, root canal retreatment, rotary instrumentation.

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Introduction

Conventional endodontic retreatment has largely replaced endodontic surgery for the management of failed root canal treatment. This has been informed by better understanding of the factors involved in post-treatment disease and the development of new instruments and techniques.

However, the removal of gutta-percha filling material, particularly from apparently well-condensed root canals (Ladley *et al.* 1991), may be time-consuming. Unfortunately, this is essential for the success of retreatment (Friedman *et al.* 1990).

Mechanical systems have been proposed as an alternative to hand instrumentation for removing gutta-percha. However, few studies (Hülsmann & Stotz 1997, Bramante & Betti 2000, Barletta & Lagranha 2002) have

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investigated and compared the effectiveness of these instruments in the removal of filling material. Therefore, the objective of the present *in vitro* study was to evaluate the effectiveness of the following techniques for filling removal during reinstrumentation of root canals: hand instrumentation with K-type files; K3 Endo rotary system (SybronEndo); M4 (SybronEndo) and Endo-gripper (Moyco Union Broach, York, PA, USA). K3 and M4 are reciprocating systems connected to an electric motor used with K-type files.

Materials and methods

Eighty extracted mandibular premolars, obtained from the 'Tooth Bank' of the Universidade Federal de Pelotas, were radiographed and selected if they had single straight canals, fully formed apices, and no calcifications or internal resorption. The teeth were decoronated at the cementoenamel junction with a double diamond disc (KG Sorensen, Barueri, Brazil) to leave a root 15–16-mm in length. Root canal contents were removed with a size 15 K-type file and 1% sodium hypochlorite (NaOCl) until the apical foramen was penetrated that was confirmed by stereomicroscopy (40× magnification). The real length of the root canal was then recorded and the working length established 1 mm short of the foramen.

The first instrument that fitted snugly at working length was identified and teeth with apical root canal diameters no greater than a size 25 file were selected. Each tooth was held in a small vice and the canal prepared with a step-back technique to a size 40 at working length, stepping back with three subsequent instruments (45, 50, 60). Irrigation with 1% NaOCl, was carried out using an irrigating needle placed 3 mm from working length. At each change of instrument, 2 mL of 1% NaOCl was used. When the instrumentation of root canals was completed, EDTA (17%) was applied for 3 min for smear layer removal and the canals flushed again with 1% NaOCl. Finally, the root canals were dried with paper points.

The root canals were then obturated with gutta-percha and zinc oxide eugenol sealer (Endofill; Dentsply, Petrópolis, RJ, Brazil) using thermomechanical compaction in a hybrid technique (Tagger *et al.* 1984). This consisted of lateral compaction of cold gutta-percha in the apical region followed by use of a rotating gutta condenser to thermally soften and condense the gutta-percha within the coronal root canal. A gutta condenser (Dentsply Maillefer, Ballaigues, Switzerland), one size greater than the last instrument used in preparation, was

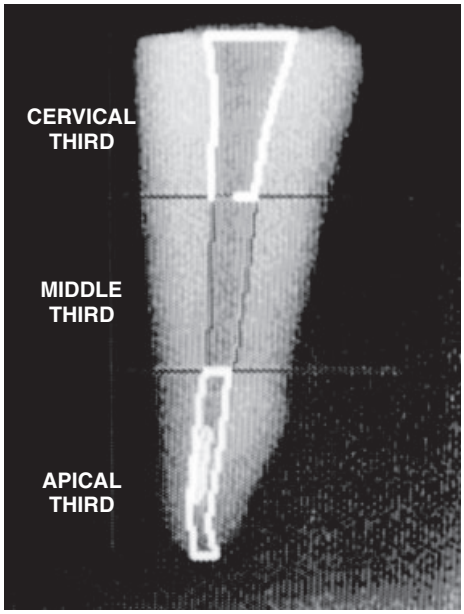

Figure 1 Filling material debris remnants in group I – Hand Technique.

applied 2 mm short of working length, with the engine operating clockwise at 8000 rpm. Mesiodistal and buccolingual radiographs (Ultraspeed Radiographic Film Kodak, Rochester, MN, USA) were taken on the same film using a lead shield to mask the half of the film not being exposed. Radiographs were taken to examine the quality and apical extent of root fillings. The specimens were sealed with a temporary filling material (Cavit; Espe Dental, Medizin, Germany) and stored at 37 °C in 100% humidity for 8 months.

After 8 months, the teeth were randomly divided into four groups of 20 specimens each. The temporary filling material was removed with a size 4 round bur (Dentsply Maillefer), thus forming a reservoir for eucalyptol (Odonto Farma, Porto Alegre, Brazil) that was used as a solvent. One drop of eucalyptol was applied to the gutta-percha for 3 min. Thereafter, penetration of the root filling mass was initiated with a size 25 K-type file. Subsequently, size 20 and size 15 K-type files were used until the working length was reached with a size 25 K-type file. After the root canal was negotiated and the working length was achieved, filling material removal continued with one of the different techniques under study. Each time an instrument was removed from the root canal, it was cleaned in gauze to remove filling material debris. At each change of instrument, the root canals were irrigated with 2 mL of 1% NaOCl and aspirated with a suction

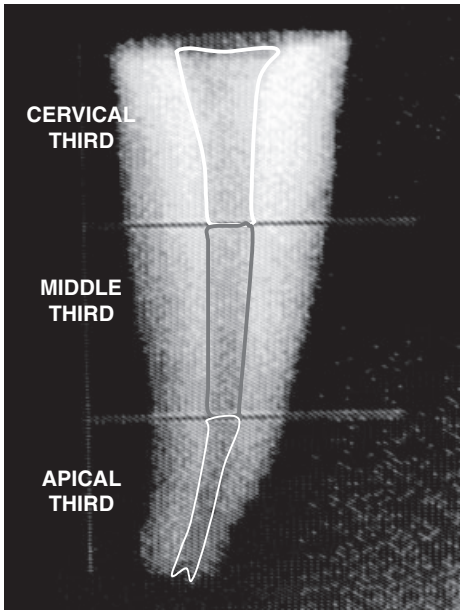

Figure 2 Result achieved in group II – K3 Endo system.

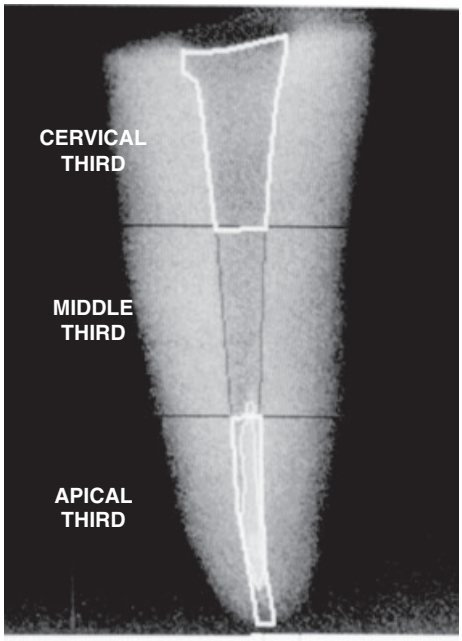

Figure 3 Filling material debris remnants in group III – M4 system.

cannula, and another drop of solvent was applied. When the instrument reached the apical third, use of solvent was discontinued.

For the reinstrumentation of root canals in all groups, the apical diameter at working length was enlarged to a size 45 file, one size larger than the last instrument used during its initial preparation. Gutta-percha removal and reinstrumentation were then considered complete unless filling material debris was observed in the instrument flutes or in the irrigating solution. The smoothness of canal walls was checked by means of tactile sensitivity using the last instrument.

Group I – control

Filling material was removed using a hand crown-down technique. Root canals were negotiated as described above, and filling removal was initiated with a size 80 K-type file (SybronEndo) and then using sequentially smaller diameters sizes 70, 60, 55, 50 and 45 towards the apex until the working length was achieved with a size 40 K-type file, which corresponded to the apical diameter established in the mechanical preparation of all specimens. Working length was then maintained, and the apical diameter was enlarged to a size 45 instrument. Complete removal of filling material was determined according to the criteria mentioned above. All instruments were introduced to the point where they met resistance by the existing filling material or by the internal anatomy of the canal. The instruments were inserted, rotated clockwise and counterclockwise, and removed.

Group II – K3

Group II was instrumented with a rotary system using K3 NiTi instruments (SybronEndo) and a crown-down technique. After root canal negotiation to working length, 0.04 taper K3 instruments, corresponding to sizes 60, 50, 45 and 40, were adjusted to working length and used in a handpiece (NSK, Schaumburg, IL, USA) connected to an electric motor (Endoplus VK Driller, São Paulo, Brazil) with a speed reduction of 16 : 1. The filling material was removed with a sequence of instruments of decreasing size operated at a constant speed of 200 rpm and a torque of 8 N cm. The instruments were introduced into the root canal with gentle in–out movements through the long axis of the canal, with amplitude of movement no greater than 3 mm. When a size 45, 0.04 taper K3 instrument reached working length and the smoothness of canals walls were judged to be good, removal was considered complete.

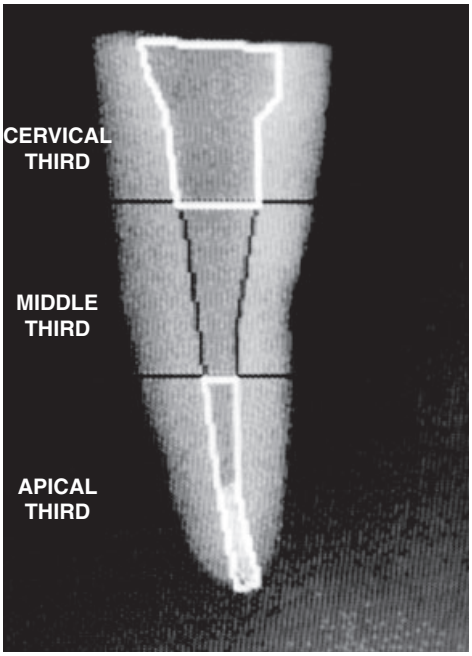

Figure 4 Filling material debris remnants in group IV – Endo-gripper system.

Group III – M4 and group IV – Endo-gripper

Reciprocating systems M4 (SybronEndo) and Endo-gripper (Moyco Union Broach) were used in association with K-type files (SybronEndo). After canals were negotiated through the filling material to working length, removal of filling material and reinstrumentation were performed according to the crown-down technique with stainless steel K-type files, beginning with a size 80 file, followed by files of successively decreasing sizes 70, 60, 55, 50, 45 and 40. All files were attached to handpieces connected to electric motor operated at a constant speed of 600 rpm and a torque of 8 N cm. The crown-down technique was performed with gentle push and pull movements towards the apex. Movement amplitude for initial penetration was not greater than 3 mm until the size 40 file achieved working length. Every time resistance to file introduction was met, pressure was applied in an attempt to unblock the canal. When the size 40 file reached working length, the apex was enlarged to a size 45 file attached to handpieces connected to electric motor. Each instrument was used up to five times.

When filling removal and reinstrumentation of the root canals were concluded, mesiodistal and buccolingual radiographs were taken using a lead shield to mask the half of the film not being exposed. Exposure time was 0.48 s, and the distance between the X-ray source and film was set at a constant distance of 5 cm. Films were automatically processed (Peri-ProII-Air Techniques, New York, NY, USA), and the images digitized using a scanner with the resolution set at 600 dpi, brightness at 132, and contrast at 142. Images were evaluated with the AutoCAD 2000 software (Mechanical Desktop Power Pack, Microsoft, Redmond, WA, USA). The mesiodistal images that had the largest area of the root canals and of the remaining filling material were selected for analysis.

Root canal walls and remaining filling material were identified by the operator through the difference of radiopacity and outlined (Figs 1–4). To outline the areas of total root canal and remaining filling material the operator used a specific program tool. Then each root canal was divided in apical, middle and cervical thirds, which were evaluated separately. To better visualize area outlines, images were assessed at 25× magnification, and their areas were automatically measured in square millimetres. As a result, measurements were 25 times greater than the real areas of root canal and debris in each third. The ratio between canal and material areas was computed as a percentage of the remaining filling material in each third of the canal. Before analysis, two specialists, blinded to the group to which each image belonged, revaluated the outline of areas made by the operator. If they did not agree with the outline areas, the measurement was repeated until consensus was reached.

For statistical analysis, measurements of means and standard deviations of areas of total root canal and remaining filling material, as well as of areas of each third and each group, were obtained. The amount of remaining filling material in the entire root and in each third did not show a normal distribution. Therefore, rank transformation was used as a classification criterion for the comparison between the four groups and the thirds. Thereafter, data were analysed by means of one-way ANOVA and the *post-hoc* Duncan test to identify differences. Level of significance was set at $P = 0.05$. Results were processed and analysed with the SPSS 10.0 software (Statistical Package for the Social Sciences Inc., Chicago, IL, USA).

Results

Measurements of the means of percentages of remaining root filling material in the different canal thirds in each group are shown in Table 1. None of the techniques was

Table 1 Mean and standard deviations (SD) of the total percentages of remaining filling material and percentages of remaining filling material in each third of root canals in the different groups

	Group I (control)		Group II (K3)		Group III (M4)		Group IV (Endo-gripper)	
Areas	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Total	6.31	3.36	3.98	3.81	6.45	4.33	5.90	3.89
Cervical	0.72	3.14	1.19	2.85	0.24	0.10	0.00	0.00
Middle	1.26	4.01	2.48	3.96	1.85	4.46	0.71	1.44
Apical	30.40	15.46	15.54	14.47	32.14	17.88	30.71	19.52

capable of completely removing filling material as detected radiographically.

Multiple comparisons by means of ANOVA and rank transformation of percentages of total remaining filling material after filling removal and reinstrumentation did not detect statistically significant differences between the groups ($\mathbf{P} = 0.131$).

However, an effect of the canal third under analysis was observed in all groups. A value of $P = 0.09$ was found for the cervical third, which, although not statistically significant, was close to the 0.05 significance level. The Endo-gripper and the K3 systems had the best and the worst outcome, respectively, in filling material removal in this third.

In the middle third, no statistically significant difference was observed between the groups ($P = 0.33$). However, the value of $P = 0.012$ for the apical third revealed a significant difference. When analysing these differences, the Duncan test detected that the mean percentage of remaining filling material for the K3 rotary system was significantly lower than the means for the others groups, whose results were similar.

Discussion

Premolar teeth were selected in this study because they are extracted commonly for orthodontic treatment. Moreover, although these canals are often straight, they are often flattened mesiodistally, an important anatomic variation during their treatment.

Unfortunately, *in vitro* studies do not fully reproduce *in vivo* conditions, and decoronation further reduces their clinical relevance. However, decoronation (Ferreira *et al.* 2001) assured standardization of specimens as it eliminated some variables, such as the anatomy of the coronal area and the access to the root canals allowing a more reliable comparison between retreatment techniques.

The present study is the first to use reciprocating systems connected to electric motors for removal of filling material. Consequently, a pilot study was conducted to establish an effective and safe speed. In addition, because these systems have different movement amplitudes, the same minimal final speed, 600 rpm, was established for the two devices. Lower speeds resulted only in gutta-percha plasticization and loss of the working length.

Torque was adjusted according to the information provided by the manufacturers. Gambarini (2000) reported that instrumentation with low torque increased tactile sensitivity and, consequently, control of rotary instrumentation. This lead to a decreased risk of ledges and perforations, which is an important factor during filling removal in endodontic retreatment. Yared *et al.* (2001) pointed out that systems powered by air could not control torque, and air pressure variation might affect the rotational speed and torque. Such findings justified the use of reciprocating systems powered by an electric motor.

Filling material removal and reinstrumentation of root canals are two associated steps. Therefore, both procedures were performed, and the canals were enlarged one diameter greater than the initial preparation. Conventional stainless steel K-type files were used with reciprocating systems as it was necessary to use an instrument with a cutting tip to remove filling material. Moreover, these instruments could be used because the specimens had straight canals.

One of the most important and critical points in the study is the method of evaluation of the amount of remaining filling material. Different methodologies have been reported: longitudinal cleavage of teeth (Friedman *et al.* 1993) which may displace debris of the material to be evaluated (Ferreira *et al.* 2001); association of longitudinal and transverse cleavage for evaluation in thirds (Imura *et al.* 2000); and cleavage and photographic recordings (Wilcox *et al.* 1987). Hülsmann & Stotz (1997) used visual examination through cleavage and photography in association with radiographic examination.

The present analysis was carried out using the method reported by Barletta & Lagranha (2002), without longitudinal cleavage and with radiographs being analysed by means of a software package developed for civil engineering and architecture, the AutoCAD 2000. However, this method has limitations as radiographic images provide only two-dimensional information on a three-dimensional structure. Moreover, the software used did not calculate the volume of

objects with irregular outlines. This justified the choice of analysing only the largest areas.

These limitations together with the anatomic variations of premolars, especially in the cervical third, may explain the abnormal distribution of the percentages of total area of remaining filling material, as in some specimens it was distributed along the root canal walls, resulting in a significantly greater height.

None of the techniques evaluated remove all filling material from root canals, a finding that is consistent with previous reports (Wilcox *et al.* 1987, Barletta & Lagranha 2002). The evaluation of total percentage of remaining filling material did not reveal any statistically significant differences in technique effectiveness for the groups studied.

However, when the analysis was stratified by thirds, a difference was revealed for the cervical third ($P = 0.09$), which, although not statistically significant, was very close to the 0.05 significance value. This result may be explained by the fact that the K3 file remains centred within the root canal during rotation and does not touch all the walls in the widest area of the canal, results consistent with the findings reported by Sae-Lim *et al.* (2000) and Barletta & Lagranha (2002). The Endo-gripper, in contrast, permits that the operator work with the file against the walls of the canal, removing more filling material, which is important for the retreatment of canals that are flattened mesiodistally.

No statistically significant difference was observed in the middle third in the different groups ($P = 0.33$), and all techniques removed filling material effectively, with indices close to zero. However, in the apical third K3 rotary system left a mean percentage of remaining filling material significantly lower ($P = 0.012$) than other groups, probably because K3 file system may fit better to the root canal walls in the apical region, where the canal becomes round. When this instrument rotated 360° inside the root canal, gutta-percha was engaged by the instrument flutes and removed.

The limited number of times each instrument was used, the initial negotiation of the canal and the use of solvent and irrigation ensures that the procedure was safe and no instrument fracture occurred, independent of the technique.

Conclusions

1. None of the techniques removed all filling material from root canals.

2. The analysis of cervical and middle thirds did not detect statistically significant differences in the groups studied.

3. There were statistically significant differences between the techniques evaluated for filling removal in the apical third: the K3 Endo rotary system left the least amount of filling material in this third of the canal.

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